High Resolution Observations of CCS($J_N = 2_1 - 1_0$): New Insight into Clumpiness of Dark Cloud Cores

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Recent observations of carbon chain molecule CCS show that it is widespread in quiescent dark clouds. The CCS lines are excellent tracers to investigate the velocity structure in the dense cores, because they have no hyperfine structure, have intrinsically narrow thermal line width ($0.09\,kms^{-1}$ at 10 K), and are not opaque. in this paper we present very high spectral resolution observations of CCS(J_N = 21 -- 1_0) transition at 22.344033 GHz in the cores of TMC-1, TMC-1C ($T_p \sim$ 2 K) and a new detection in 11335 ($T_p \sim$ 0.3 K). The spectra were obtained using NASA's 70-m antenna at Goldstone (with resolution of 45"). The two million channel Wide Band Spectrum Analyzer (resolution 19 Hz per channel) was used to obtain spectra with unprecedented velocity resolution of 0.008 kms^{-1}. The system temperature was $\sim$60 K. These spectra are fully resolved showing multiple clumps within the beam with narrow line widths ($\sim 0.1 kms^{-1}$) consistent with thermal broadening at 10 K and little or no turbulence. The spectral line profiles at each observed positions can be best fitted with several, about 3 to 10 clumps each with AV $\sim$ 0.1 kms^{-1}. It has been possible to trace these clumps spatially also in the spectra at adjacent positions, We find the number of clumps in these cores to be larger by a factor of 3 to 4 than that estimated from lower resolution spectra, and its relevence to the mass spectra of the clumps in dense cores of dark clouds is discussed. The brightest and broadest spectrum in" B335 is observed at the position of the protostellar collapse region, suggesting an increase in the number density of clumps in the collapse region.

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